

What Is Claimed Is:

1. A fuel discharge apparatus for use in a fuel supply system of an internal combustion engine, said fuel discharge apparatus comprising:

a fuel discharge apparatus body;

a fuel chamber defined within said fuel discharge apparatus body;

a fuel inlet adapted to be fluidically connected to a fuel tank;

a fuel supply path at least partially defined by said fuel inlet and fluidically connected to said fuel chamber to supply fuel from the fuel tank to said fuel chamber;

a fuel discharge outlet fluidically connected to said fuel chamber for discharging fuel from said fuel chamber;

a fuel return outlet adapted to be fluidically connected to the fuel tank to allow return of excess fuel to the fuel tank;

a reflux path defined in said fuel discharge apparatus body and being fluidically connected between said fuel supply path and said fuel return outlet to allow flow of the excess fuel from said fuel supply path to said fuel return outlet, said reflux path being connected to said fuel supply path at a bifurcation point; and

a vapor blocking member provided in said fuel supply path at said bifurcation point to block entry of vapor into said fuel chamber;

wherein said reflux path is arranged such that the vapor blocked by said vapor blocking member rises from said bifurcation point and through said reflux path to said fuel return outlet due to self-buoyancy of the vapor.

2. A fuel discharge apparatus according to claim 1, wherein said fuel return outlet is disposed vertically above said bifurcation point.

3. A fuel discharge apparatus according to claim 1, further comprising an inlet check valve disposed in said fuel supply path between said bifurcation point and said fuel chamber.

4. A fuel discharge apparatus according to claim 1, further comprising a plunger pump disposed in said fuel discharge apparatus body, said plunger pump comprising a cylinder mounted in said fuel discharge apparatus body, a plunger slidably disposed in said cylinder for reciprocating movement therein, and a solenoid coil disposed around said cylinder for actuating said plunger to slide within said cylinder; and

wherein said reflux path extends in an axial direction of said plunger pump between said cylinder and said solenoid coil.

5. A fuel discharge apparatus according to claim 1, wherein said reflux path is connected to said fuel supply path at a bifurcation point in such a manner that said reflux path branches off from said fuel supply path at said bifurcation point and originates at said fuel supply path and leads from said fuel supply path to said fuel return outlet.

6. A fuel discharge apparatus according to claim 1, further comprising a fuel injection nozzle provided at said fuel discharge outlet.

7. A fuel discharge apparatus according to claim 6, further comprising a plunger pump disposed in said fuel discharge apparatus body and operably connected with said fuel chamber to pressurize fuel in said fuel chamber to thereby enable discharge of the fuel from said fuel discharge outlet through said fuel injection nozzle.

8. A fuel discharge apparatus according to claim 1, wherein said bifurcation point is disposed within said fuel discharge apparatus body.

9. A fuel discharge apparatus according to claim 1, wherein said vapor blocking member comprises a surface tension generating member.

10. A fuel discharge apparatus according to claim 9, wherein said surface tension generating member comprises a porous paper sheet.

11. A fuel discharge apparatus according to claim 9, wherein said surface tension generating member comprises a perforated metal plate.

12. A fuel discharge apparatus according to claim 9, wherein said surface tension generating member comprises a porous sintered body.

13. A fuel discharge apparatus according to claim 9, wherein said surface tension generating member comprises a non-woven fabric.

14. A fuel discharge apparatus for use in a fuel supply system of an internal combustion engine, said fuel discharge apparatus comprising:

a fuel discharge apparatus body;

a fuel chamber defined within said fuel discharge apparatus body;

a fuel inlet adapted to be fluidically connected to a fuel tank;

a fuel supply path at least partially defined by said fuel inlet and fluidically connected to said fuel chamber to supply fuel from the fuel tank to said fuel chamber;

a fuel discharge outlet fluidically connected to said fuel chamber for discharging fuel from said fuel chamber;

a fuel return outlet adapted to be fluidically connected to the fuel tank to allow return of excess fuel to the fuel tank;

a reflux path defined in said fuel discharge apparatus body and being fluidically connected between said fuel supply path and said fuel return outlet to allow flow of the excess fuel from said fuel supply path to said fuel return outlet, said reflux path being connected to said fuel supply path at a bifurcation point;

a vapor blocking member provided in said fuel supply path at said bifurcation point to block entry of vapor into said fuel chamber; and

an inlet check valve disposed in said fuel supply path between said bifurcation point and said fuel chamber.

15. A fuel discharge apparatus according to claim 14, further comprising a plunger pump disposed in said fuel discharge apparatus body, said plunger pump comprising a cylinder mounted in said fuel discharge apparatus body, a plunger slidably disposed in said cylinder for reciprocating movement therein, and a solenoid coil disposed around said cylinder for actuating said plunger to slide within said cylinder; and

wherein said reflux path extends in an axial direction of said plunger pump between said cylinder and said solenoid coil.

16. A fuel discharge apparatus according to claim 14, wherein said reflux path is connected to said fuel supply path at a bifurcation point in such a manner that said reflux path branches off from said fuel supply path at said bifurcation point and originates at said fuel supply path and leads from said fuel supply path to said fuel return outlet.

17. A fuel discharge apparatus according to claim 14, further comprising a fuel injection nozzle provided at said fuel discharge outlet.

18. A fuel discharge apparatus according to claim 17, further comprising a plunger pump disposed in said fuel discharge apparatus body and operably connected with said fuel

chamber to pressurize fuel in said fuel chamber to thereby enable discharge of the fuel from said fuel discharge outlet through said fuel injection nozzle.

19. A fuel discharge apparatus according to claim 14, wherein said bifurcation point is disposed within said fuel discharge apparatus body.

20. A fuel discharge apparatus according to claim 14, wherein said vapor blocking member comprises a surface tension generating member.

21. A fuel discharge apparatus for use in a fuel supply system of an internal combustion engine, said fuel discharge apparatus comprising:

a fuel discharge apparatus body;

a fuel chamber defined within said fuel discharge apparatus body;

a fuel inlet adapted to be fluidically connected to a fuel tank;

a fuel supply path at least partially defined by said fuel inlet and fluidically connected to said fuel chamber to supply fuel from the fuel tank to said fuel chamber;

a fuel discharge outlet fluidically connected to said fuel chamber for discharging fuel from said fuel chamber;

a fuel return outlet adapted to be fluidically connected to the fuel tank to allow return of excess fuel to the fuel tank;

a reflux path defined in said fuel discharge apparatus body and being fluidically connected between said fuel supply path and said fuel return outlet to allow flow of the excess fuel from said fuel supply path to said fuel return outlet, said reflux path being connected to said fuel supply path at a bifurcation point;

a vapor blocking member provided in said fuel supply path at said bifurcation point to block entry of vapor into said fuel chamber; and

a plunger pump disposed in said fuel discharge apparatus body, said plunger pump comprising a cylinder mounted in said fuel discharge apparatus body, a plunger slidably disposed in said cylinder for reciprocating movement therein, and a solenoid coil disposed around said cylinder for actuating said plunger to slide within said cylinder;

wherein said reflux path extends in an axial direction of said plunger pump between said cylinder and said solenoid coil.

22. A fuel discharge apparatus according to claim 21, wherein said reflux path is connected to said fuel supply path at

a bifurcation point in such a manner that said reflux path branches off from said fuel supply path at said bifurcation point and originates at said fuel supply path and leads from said fuel supply path to said fuel return outlet.

23. A fuel discharge apparatus according to claim 21, further comprising a fuel injection nozzle provided at said fuel discharge outlet.

24. A fuel discharge apparatus according to claim 23, further comprising a plunger pump disposed in said fuel discharge apparatus body and operably connected with said fuel chamber to pressurize fuel in said fuel chamber to thereby enable discharge of the fuel from said fuel discharge outlet through said fuel injection nozzle.

25. A fuel discharge apparatus according to claim 21, wherein said bifurcation point is disposed within said fuel discharge apparatus body.

26. A fuel discharge apparatus according to claim 21, wherein said vapor blocking member comprises a surface tension generating member.

27. A fuel discharge apparatus for use in a fuel supply system of an internal combustion engine, said fuel discharge apparatus comprising:

a fuel discharge apparatus body;

a fuel chamber defined within said fuel discharge apparatus body;

a fuel inlet adapted to be fluidically connected to a fuel tank;

a fuel supply path at least partially defined by said fuel inlet and fluidically connected to said fuel chamber to supply fuel from the fuel tank to said fuel chamber;

a fuel discharge outlet fluidically connected to said fuel chamber for discharging fuel from said fuel chamber;

a fuel return outlet adapted to be fluidically connected to the fuel tank to allow return of excess fuel to the fuel tank;
and

a reflux path defined in said fuel discharge apparatus body and being fluidically connected between said fuel supply path and said fuel return outlet to allow flow of the excess fuel from said fuel supply path to said fuel return outlet;

wherein said reflux path is connected to said fuel supply path at a bifurcation point in such a manner that said reflux path branches off from said fuel supply path at said bifurcation

point and originates at said fuel supply path and leads from said fuel supply path to said fuel return outlet; and

wherein a vapor blocking member is provided in said fuel supply path at said bifurcation point to block entry of vapor into said fuel chamber.

28. A fuel discharge apparatus according to claim 27, further comprising a fuel injection nozzle provided at said fuel discharge outlet.

29. A fuel discharge apparatus according to claim 28, further comprising a plunger pump disposed in said fuel discharge apparatus body and operably connected with said fuel chamber to pressurize fuel in said fuel chamber to thereby enable discharge of the fuel from said fuel discharge outlet through said fuel injection nozzle.

30. A fuel discharge apparatus according to claim 27, wherein said bifurcation point is disposed within said fuel discharge apparatus body.

31. A fuel discharge apparatus according to claim 27, wherein said vapor blocking member comprises a surface tension generating member.

32. A fuel supply system for an internal combustion engine, said fuel supply system including a fuel tank, a fuel discharge apparatus, a fuel supply passage connecting said fuel discharge apparatus to said fuel tank to enable supply of fuel from said fuel tank to said fuel discharge apparatus and a return passage connecting said fuel tank to said fuel discharge apparatus to enable return of excess fuel from said fuel discharge apparatus to said fuel tank, said fuel discharge apparatus comprising:

- a fuel discharge apparatus body;

- a fuel chamber defined within said fuel discharge apparatus body;

- a fuel inlet fluidically connected to said fuel tank;

- a fuel supply path at least partially defined by said fuel inlet and fluidically connected to said fuel chamber to supply fuel from said fuel tank to said fuel chamber;

- a fuel discharge outlet fluidically connected to said fuel chamber for discharging fuel from said fuel chamber;

- a fuel return outlet fluidically connected to said fuel tank via said return passage to allow return of excess fuel to said fuel tank;

- a reflux path defined in said fuel discharge apparatus body and being fluidically connected between said fuel supply path and said fuel return outlet to allow flow of the excess fuel from

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said fuel supply path to said fuel return outlet, said reflux path being connected to said fuel supply path at a bifurcation point; and

a vapor blocking member provided in said fuel supply path at said bifurcation point to block entry of vapor into said fuel chamber;

wherein said reflux path is arranged such that the vapor blocked by said vapor blocking member rises from said bifurcation point and through said reflux path to said fuel return outlet due to self-buoyancy of the vapor.

33. A fuel supply system according to claim 32, wherein said fuel return outlet is disposed vertically above said bifurcation point.

34. A fuel supply system according to claim 32, further comprising a fuel pump operably coupled in said fuel supply passage so as to be located downstream of said fuel tank and upstream of said bifurcation point.

35. A fuel supply system according to claim 32, further comprising an inlet check valve disposed in said fuel supply path between said bifurcation point and said fuel chamber.

36. A fuel supply system according to claim 32, further comprising a plunger pump disposed in said fuel discharge apparatus body, said plunger pump comprising a cylinder mounted in said fuel discharge apparatus body, a plunger slidably disposed in said cylinder for reciprocating movement therein, and a solenoid coil disposed around said cylinder for actuating said plunger to slide within said cylinder; and

wherein said reflux path extends in an axial direction of said plunger pump between said cylinder and said solenoid coil.

37. A fuel supply system according to claim 32, wherein said reflux path is connected to said fuel supply path at a bifurcation point in such a manner that said reflux path branches off from said fuel supply path at said bifurcation point and originates at said fuel supply path and leads from said fuel supply path to said fuel return outlet.

38. A fuel supply system according to claim 32, further comprising a fuel injection nozzle provided at said fuel discharge outlet.

39. A fuel supply system according to claim 38, further comprising a plunger pump disposed in said fuel discharge apparatus body and operably connected with said fuel chamber to

pressurize fuel in said fuel chamber to thereby enable discharge of the fuel from said fuel discharge outlet through said fuel injection nozzle.

40. A fuel supply system according to claim 32, wherein said bifurcation point is disposed within said fuel discharge apparatus body.

41. A fuel supply system according to claim 32, wherein said vapor blocking member comprises a surface tension generating member.

42. A fuel supply system according to claim 41, wherein said surface tension generating member comprises a porous paper sheet.

43. A fuel supply system according to claim 41, wherein said surface tension generating member comprises a perforated metal plate.

44. A fuel supply system according to claim 41, wherein said surface tension generating member comprises a porous sintered body.

45. A fuel supply system according to claim 41, wherein said surface tension generating member comprises a non-woven fabric.

46. A fuel supply system for an internal combustion engine, said fuel supply system including a fuel tank, a fuel discharge apparatus, a fuel supply passage connecting said fuel discharge apparatus to said fuel tank to enable supply of fuel from said fuel tank to said fuel discharge apparatus and a return passage connecting said fuel tank to said fuel discharge apparatus to enable return of excess fuel from said fuel discharge apparatus to said fuel tank, said fuel discharge apparatus comprising:

- a fuel discharge apparatus body;

- a fuel chamber defined within said fuel discharge apparatus body;

- a fuel inlet fluidically connected to said fuel tank;

- a fuel supply path at least partially defined by said fuel inlet and fluidically connected to said fuel chamber to supply fuel from said fuel tank to said fuel chamber;

- a fuel discharge outlet fluidically connected to said fuel chamber for discharging fuel from said fuel chamber;

- a fuel return outlet fluidically connected to said fuel tank via said return passage to allow return of excess fuel to said fuel tank;

a reflux path defined in said fuel discharge apparatus body and being fluidically connected between said fuel supply path and said fuel return outlet to allow flow of the excess fuel from said fuel supply path to said fuel return outlet, said reflux path being connected to said fuel supply path at a bifurcation point;

a vapor blocking member provided in said fuel supply path at said bifurcation point to block entry of vapor into said fuel chamber; and

an inlet check valve disposed in said fuel supply path between said bifurcation point and said fuel chamber.

47. A fuel supply system according to claim 46, further comprising a fuel pump operably coupled in said fuel supply passage so as to be located downstream of said fuel tank and upstream of said bifurcation point.

48. A fuel supply system according to claim 46, further comprising a plunger pump disposed in said fuel discharge apparatus body, said plunger pump comprising a cylinder mounted in said fuel discharge apparatus body, a plunger slidably disposed in said cylinder for reciprocating movement therein, and a solenoid coil disposed around said cylinder for actuating said plunger to slide within said cylinder; and

wherein said reflux path extends in an axial direction of said plunger pump between said cylinder and said solenoid coil.

49. A fuel supply system according to claim 46, wherein said reflux path is connected to said fuel supply path at a bifurcation point in such a manner that said reflux path branches off from said fuel supply path at said bifurcation point and originates at said fuel supply path and leads from said fuel supply path to said fuel return outlet.

50. A fuel supply system according to claim 46, further comprising a fuel injection nozzle provided at said fuel discharge outlet.

51. A fuel supply system according to claim 50, further comprising a plunger pump disposed in said fuel discharge apparatus body and operably connected with said fuel chamber to pressurize fuel in said fuel chamber to thereby enable discharge of the fuel from said fuel discharge outlet through said fuel injection nozzle.

52. A fuel supply system according to claim 46, wherein said bifurcation point is disposed within said fuel discharge apparatus body.

53. A fuel supply system according to claim 46, wherein said vapor blocking member comprises a surface tension generating member.

54. A fuel supply system for an internal combustion engine, said fuel supply system including a fuel tank, a fuel discharge apparatus, a fuel supply passage connecting said fuel discharge apparatus to said fuel tank to enable supply of fuel from said fuel tank to said fuel discharge apparatus and a return passage connecting said fuel tank to said fuel discharge apparatus to enable return of excess fuel from said fuel discharge apparatus to said fuel tank, said fuel discharge apparatus comprising:

- a fuel discharge apparatus body;

- a fuel chamber defined within said fuel discharge apparatus body;

- a fuel inlet fluidically connected to said fuel tank;

- a fuel supply path at least partially defined by said fuel inlet and fluidically connected to said fuel chamber to supply fuel from said fuel tank to said fuel chamber;

- a fuel discharge outlet fluidically connected to said fuel chamber for discharging fuel from said fuel chamber;

a fuel return outlet fluidically connected to said fuel tank via said return passage to allow return of excess fuel to said fuel tank;

a reflux path defined in said fuel discharge apparatus body and being fluidically connected between said fuel supply path and said fuel return outlet to allow flow of the excess fuel from said fuel supply path to said fuel return outlet, said reflux path being connected to said fuel supply path at a bifurcation point;

a vapor blocking member provided in said fuel supply path at said bifurcation point to block entry of vapor into said fuel chamber; and

a plunger pump disposed in said fuel discharge apparatus body, said plunger pump comprising a cylinder mounted in said fuel discharge apparatus body, a plunger slidably disposed in said cylinder for reciprocating movement therein, and a solenoid coil disposed around said cylinder for actuating said plunger to slide within said cylinder;

wherein said reflux path extends in an axial direction of said plunger pump between said cylinder and said solenoid coil.

55. A fuel supply system according to claim 54, further comprising a fuel pump operably coupled in said fuel supply

passage so as to be located downstream of said fuel tank and upstream of said bifurcation point.

56. A fuel supply system according to claim 54, wherein said reflux path is connected to said fuel supply path at a bifurcation point in such a manner that said reflux path branches off from said fuel supply path at said bifurcation point and originates at said fuel supply path and leads from said fuel supply path to said fuel return outlet.

57. A fuel supply system according to claim 54, further comprising a fuel injection nozzle provided at said fuel discharge outlet.

58. A fuel supply system according to claim 57, further comprising a plunger pump disposed in said fuel discharge apparatus body and operably connected with said fuel chamber to pressurize fuel in said fuel chamber to thereby enable discharge of the fuel from said fuel discharge outlet through said fuel injection nozzle.

59. A fuel supply system according to claim 54, wherein said bifurcation point is disposed within said fuel discharge apparatus body.

60. A fuel supply system according to claim 54, wherein said vapor blocking member comprises a surface tension generating member.

61. A fuel supply system for an internal combustion engine, said fuel supply system including a fuel tank, a fuel discharge apparatus, a fuel supply passage connecting said fuel discharge apparatus to said fuel tank to enable supply of fuel from said fuel tank to said fuel discharge apparatus and a return passage connecting said fuel tank to said fuel discharge apparatus to enable return of excess fuel from said fuel discharge apparatus to said fuel tank, said fuel discharge apparatus comprising:

- a fuel discharge apparatus body;

- a fuel chamber defined within said fuel discharge apparatus body;

- a fuel inlet fluidically connected to said fuel tank;

- a fuel supply path at least partially defined by said fuel inlet and fluidically connected to said fuel chamber to supply fuel from said fuel tank to said fuel chamber;

- a fuel discharge outlet fluidically connected to said fuel chamber for discharging fuel from said fuel chamber;

a fuel return outlet fluidically connected to said fuel tank via said return passage to allow return of excess fuel to said fuel tank; and

a reflux path defined in said fuel discharge apparatus body and being fluidically connected between said fuel supply path and said fuel return outlet to allow flow of the excess fuel from said fuel supply path to said fuel return outlet;

wherein said reflux path is connected to said fuel supply path at a bifurcation point in such a manner that said reflux path branches off from said fuel supply path at said bifurcation point and originates at said fuel supply path and leads from said fuel supply path to said fuel return outlet; and

wherein a vapor blocking member is provided in said fuel supply path at said bifurcation point to block entry of vapor into said fuel chamber.

62. A fuel supply system according to claim 61, further comprising a fuel pump operably coupled in said fuel supply passage so as to be located downstream of said fuel tank and upstream of said bifurcation point.

63. A fuel supply system according to claim 61, further comprising a fuel injection nozzle provided at said fuel discharge outlet.

64. A fuel supply system according to claim 63, further comprising a plunger pump disposed in said fuel discharge apparatus body and operably connected with said fuel chamber to pressurize fuel in said fuel chamber to thereby enable discharge of the fuel from said fuel discharge outlet through said fuel injection nozzle.

65. A fuel supply system according to claim 61, wherein said bifurcation point is disposed within said fuel discharge apparatus body.

66. A fuel supply system according to claim 61, wherein said vapor blocking member comprises a surface tension generating member.